

CLAIMS:

1. A process to produce a predictive data set which can be used to predict the property of a plating solution, said process comprising:
  - (a) obtaining a sample set, wherein each sample comprises a plating solution of good performance;
  - (b) obtaining an electroanalytical response for each said sample to produce a electroanalytical response data set;
  - (c) obtaining a training set that comprises said sample set and corresponding said electroanalytical response data set;
  - (d) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set; and
  - (e) validating said training data set to produce said predictive data set for a predictive model.
2. A process of claim 1 wherein said property is selected from the group consisting of:
  - a concentration of individual component of said electroplating bath;
  - an amount of breakdown products accumulated in said electroplating bath;
  - an amount of foreign contaminants accumulated in said electroplating bath;
  - a temperature of said electroplating bath;
  - a quantity of hysteresis on recorded voltammogram;
  - or combinations thereof.
3. A process of claim 1, wherein said property comprises an overall plating performance.
4. A process of claim 3, wherein said overall plating performance is selected from the group consisting of:
  - throwing power;

brightness of the deposit;  
tensile strengths of the deposit;  
ductility of the deposit;  
internal stress of the deposit;  
solderability performance;  
resistance to thermal shock;  
uniformity of the deposit;  
capability of uniform filling through holes;  
capability of filling submicron features in a substrate surface;  
and combinations thereof.

5. A process according to claim 1, wherein said plating solution is an electroplating bath.

6. A process of claim 5, wherein said electroplating bath comprises a plating bath of one or metal selected from the following group: Cu, Sn, Pb, Zn, Ni, Ag, Cd, Co, Cr, and/or their alloys.

7. A process according to claim 1, wherein said plating solution is an electroless plating bath.

8. A process of claim 7, wherein said electroless plating bath comprises an autocatalytic plating bath of one or metal selected from the following group: Cu, Sn, Pb, Ni, Ag, Au, and/or their alloys.

9. A process of claim 7, wherein said electroless plating bath comprises an immersion plating bath of one or metal selected from the following group: Cu, Sn, Pb, Ni, Ag, Au and/or their alloys.

10. A process according to claim 1, wherein said plating solution is selected from the group consisting of:

an electrowinning bath;  
an electrorefining bath;  
an electropolishing bath;  
an electroforming bath; or  
an electromicromachining bath.

11. A process of claims 10, wherein said electroplating bath comprises a plating bath of one or metal selected from the following group: Cu, Sn, Pb, Zn, Ni, Ag, Cd, Co, Cr, and/or their alloys.

12. A process of claim 1, wherein the sample set of step (a) comprises plating solutions of known concentration within specification range.

13. A process according to claim 1, wherein the sample data set of step (a) is obtained by design of experiment (DOE) routines.

14. A process according to claim 13, wherein said DOE routine is multicomponent multilevel linear orthogonal array.

15. A process according to claim 13, wherein said DOE routine is multicomponent multilevel fractional factorial.

16. A process of claim 1, wherein the sample set of step (a) comprises freshly prepared electroplating solutions of known concentration within specification range.

17. A process of claim 1, wherein said sample set of step (a) comprises industrial plating solutions with well performance (empirical sample set).

18. A process according to claim 1, wherein the electroanalytical response of step (b) is obtained by DC Voltammetry.
19. A process of claim 18, wherein the DC Voltammetry comprises DC cyclic Voltammetry.
20. A process of claim 18, wherein the DC Voltammetry comprises DC Linear Scan Voltammetry.
21. A process of claim 18, wherein the DC Voltammetry comprises DC Anodic Stripping Voltammetry.
22. A process of claim 18, wherein the DC Voltammetry comprises DC Cathodic Stripping Voltammetry.
23. A process of claim 18, wherein the DC Voltammetry comprises DC Adsorptive Stripping Voltammetry.
24. A process of claim 19, wherein the DC Voltammetry comprises DC Cyclic Voltammetric Stripping technique.
25. A process according to claim 1, wherein the electroanalytical response of step (b) is obtained by a technique selected from the group consisting of:

DC Staircase Voltammetry;  
Normal Pulse Voltammetry;  
Reverse Pulse Voltammetry;  
Differential Pulse Voltammetry;  
Square Wave Voltammetry;  
AC Voltammetry;

Chronoamperometry;  
Chronopotentiometry;  
Electrochemical Impedance Spectroscopy technique;  
Polarographic techniques;  
or combinations thereof.

26. A process according to claim 1, wherein said electroanalytical response of step (b) comprises a plurality of data points.

27. A process according to claim 1, wherein said electroanalytical response of step (b) is a combination of one or more portions of a complete electroanalytical response.

28. A process according to claim 1, wherein said electroanalytical response of step (b) comprises a combination of one or more portions of independent electroanalytical responses.

29. A process of claim 1, wherein said decomposition method of step (d) is selected from the group of:

Principal Component Analysis (PCA);  
calculation of Mahalanobis Distance (MD);  
calculation of Mahalanobis Distance with residuals (MDR);  
calculation by Simple Modeling of Class Analogy (SIMCA);  
calculation of  $F^s$  ratio;  
internal validation;  
external validation;  
an combinations thereof.

30. A process to predict the property of said plating solution, said process comprising:  
(a) producing a predictive data set, the predictive data set generated by:

- (a1) obtaining a sample set, wherein each sample comprises an electrolyte solution of good performance;
- (a2) obtaining an electroanalytical response for each said sample to produce an electroanalytical response data set;
- (a3) obtaining a training set that comprises said sample set and corresponding said electroanalytical response data set;
- (a4) preprocessing of said electroanalytical response data set;
- (a5) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set;
- (a6) validating said training data set to produce said predictive data set for a predictive model; and
- (b) using said predictive data set to predict the property of said plating solution, said property predicted by:
  - (b1) obtaining an unknown sample set, wherein each unknown sample in said unknown sample set contains a plating solution;
  - (b2) obtaining an electroanalytical response for each said unknown sample to produce an electroanalytical response data set;
  - (b3) preprocessing of said electroanalytical response data set; and
  - (b4) applying said predictive model to predict property of each said unknown sample.

31. A process to detect faulty performance of said plating solution, said process comprising:

- (a) producing a predictive data set, the predictive data set generated by:
  - (a1) obtaining a sample set, wherein each sample comprises an electrolyte solution of good performance;
  - (a2) obtaining an electroanalytical response for each said sample to produce an electroanalytical response data set;
  - (a3) obtaining a training set that comprises said sample set and corresponding said electroanalytical response data set;
  - (a4) preprocessing of said electroanalytical response data set;

- (a5) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set;
- (a6) validating said training data set to produce said predictive data set for a predictive model; and
- (a7) specifying the limits of good and faulty performance of said plating solution; and
- (b) using said predictive data set to predict the property of said plating solution and qualify said solution as correct or faulty said process comprises:
  - (b1) obtaining an unknown sample set, wherein each unknown sample in said unknown sample set contains a plating solution;
  - (b2) obtaining an electroanalytical response for each said unknown sample to produce an electroanalytical response data set;
  - (b3) preprocessing of said electroanalytical response data set;
  - (b4) applying said predictive model to predict property of each said unknown sample; and
  - (b5) qualifying said unknown samples as correct or faulty.

32. A method of monitoring performance of plating solution in order to perform controlled feed and bleed procedure, said process comprising the steps of:

- (a) producing a predictive data set, the predictive data set generated by:
  - (a1) obtaining a sample set, wherein each sample comprises an electrolyte solution of good performance;
  - (a2) obtaining an electroanalytical response for each said sample to produce an electroanalytical response data set;
  - (a3) obtaining a training set that comprises said sample set and corresponding said electroanalytical response data set;
  - (a4) preprocessing of said electroanalytical response data set;
  - (a5) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set;

- (a6) validating said training data set to produce said predictive data set for a predictive model;
- (a7) defining the limits of said property for said plating solution that requires feed and bleed procedure; and
- (b) using said predictive data set to predict the property of said plating solution and qualify said solution as correct or faulty said process comprises:
  - (b1) obtaining an unknown sample set, wherein each unknown sample in said unknown sample set contains a plating solution;
  - (b2) obtaining an electroanalytical response for each said unknown sample to produce an electroanalytical response data set;
  - (b3) preprocessing of said electroanalytical response data set;
  - (b4) applying said predictive model to predict property of each said unknown sample;
- and
- (b5) qualifying said unknown samples as a ready or not ready solution for feed and bleed procedure.

33. A method of monitoring performance of electroplating solution in order to perform controlled purification treatment procedure, said process comprising the steps of:

- (a) producing a predictive data set, the predictive data set generated by:
  - (a1) obtaining a sample set, wherein each sample comprises an electrolyte solution of good performance;
  - (a2) obtaining an electroanalytical response for each said sample to produce an electroanalytical response data set;
  - (a3) obtaining a training set that comprises said sample set and corresponding said electroanalytical response data set;
  - (a4) preprocessing of said electroanalytical response data set;
  - (a5) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set;
  - (a6) validating said training data set to produce said predictive data set for a predictive model; and



- (a7) defining the limits of said property for said plating solution that requires purification treatment; and
- (b) using said predictive data set to predict the property of said plating solution and qualify said solution as correct or faulty said process comprises:
  - (b1) obtaining an unknown sample set, wherein each unknown sample in said unknown sample set contains a plating solution;
  - (b2) obtaining an electroanalytical response for each said unknown sample to produce an electroanalytical response data set;
  - (b3) preprocessing of said electroanalytical response data set;
  - (b4) applying said predictive model to predict property of each said unknown sample;
- and
- (b5) qualifying said unknown samples as ready or not ready for purification treatment.

34. A method of monitoring of performance of measuring system in order to detect its malfunctioning, said process comprising the steps of:

- (a) producing a predictive data set, the predictive data set generated by:
  - (a1) obtaining a training set, wherein each sample comprises an electronic characteristic of a measurement system of good performance;
  - (a2) preprocessing of said training data set;
  - (a3) analyzing said training set using decomposition method coupled with discriminant analysis method to produce a discriminant parameters data set;
  - (a4) validating said training data set to produce said predictive data set for a predictive model; and
  - (a5) defining the limits of said property for said electronic characteristic of the well performed measurement system; and
- (b) using said predictive data set to predict the malfunctioning of measurement system said process comprises:
  - (b1) obtaining a second data set, wherein each sample comprises an a periodically taken electronic characteristic of a measurement system ;
  - (b2) preprocessing of said second data set;

(b3) applying said predictive model to predict property of each sample of a second data set; and

(b4) detecting malfunctioning of measurement system by qualifying said property as a fault.